Efficacious Treatment of Children With Childhood Apraxia of Speech According to the International Classification of Functioning, Disability and Health

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Efficacious Treatment of Children With Childhood Apraxia of Speech According to the International Classification of Functioning, Disability and Health

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Abstract

There is increasing evidence for treatment approaches designed for children with childhood apraxia of speech (CAS). Despite this, no treatment has conclusive evidence to date. The CAS population is heterogeneous, with children presenting with varying symptom profiles, severity levels, and comorbidities. Consequently, treatment planning for children with CAS represents a clinical challenge. To assist clinicians in providing optimal care, this paper uses the International Classification of Functioning, Disability and Health (ICF) as a framework for identifying the body structures and functions, activities, and personal/environmental factors that should be considered when working with children with CAS. Evidence-based interventions are described and resources outlined to help guide the treatment planning process.

There are many treatments available for childhood apraxia of speech (CAS), which can make it hard to decide which one to use for a specific client (Morgan & Vogel, 2008; Murray, McCabe, & Ballard, 2014). Different treatments are likely needed for children of different ages, abilities, and severity levels. The International Classification of Functioning, Disability and Health (ICF) is a classification system designed to help clinicians assess a child's strengths and challenges (WHO, 2002). The ICF allows us to consider how a disability impacts body structure and functioning and how these impairments affect daily activities and participation in a range of contexts. In addition, this framework encourages us to consider to what extent different personal and environmental factors may positively or negatively impact the life and remediation of the affected individual. This paper uses the ICF to provide a big picture view of children with CAS and emphasizes which evidence-based treatments may be optimal for the varying profiles exhibited by children in this population.

It is essential to understand the underlying mechanism of CAS to know how to best treat children with the disorder. The current consensus is that CAS is a neurological, motor speech disorder of disrupted motor planning and programming in the absence of abnormal structures or tone (The American Speech-Language-Hearing Association [ASHA], 2007). The planning and programming impairment means that children with CAS have difficulty transforming their phonological representation (i.e., abstract concepts of speech sounds and syllables) into motor plans (i.e., the spatial and temporal coordinates of how to say the sounds and syllables needed in real time) and motor programs (i.e., the muscle-specific commands including range and strength of movement before executing the movements; Terband, Maassen, Guenther, & Brumberg, 2009; van der Merwe, 2009). The underlying impairment produces the symptoms that are associated with CAS such as inconsistent speech production when repeatedly saying phonemes, words or phrases, difficulty sequencing syllables, and inappropriate prosody including disturbances to lexical and phrasal stress (ASHA, 2007). These impairments become primary therapy goals for children with CAS. We also need to look broader than this, however, to ensure that our work addresses functional communication needs and that any comorbidities or risk factors associated with CAS are identified and treated as needed. In this paper, the affected Body Structures and Functions (impairment-level treatment) associated with CAS are introduced, followed by a discussion of the effects of these impairments on Activities and Participation, and finally we consider the Personal and Environmental factors that may impact treatment success.

When working with a child with CAS, frequent assessment is required in order to monitor changes associated with treatment and maturation (ASHA, 2007). Additionally, outcome measures are required to determine treatment-related changes in order to provide accountability to funders and families (Olswang & Bain, 2013). Likewise, it is essential to regularly assess the child's functional communication ability as communicative loads and demands increase and evolve over time. The preceding Iuzzini-Seigel and Murray article supports the use of the ICF to guide assessment of children with suspected or diagnosed CAS.

In parallel to the ICF, evidence-based practice aids treatment planning by helping clinicians determine and integrate: (a) clinical expertise, (b) the best available external scientific evidence, and (c) client, patient and/or caregiver needs, values, and preferences (ASHA, 2004). Evidence from peer-reviewed journal articles and conference presentations is important to consider when making treatment decisions because well-designed research reduces confirmation, measurement and internal validity biases in decision making (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996) and it assists in comparing and applying the dozens of approaches reported in the literature.

The evidence base for CAS has increased significantly in the past decade since the ASHA Technical Report on CAS (2007) alleviated some controversy surrounding CAS as a diagnosis. Presently, treatment of CAS has drawn the attention of many research teams and numerous treatment research articles have been published in the last five years, including the first randomized control trial (RCT; Murray, McCabe, & Ballard, 2015). Overall there are now treatments that demonstrate efficacy, however, most are tested on subgroups of children with CAS. It is likely that there are different approaches that appear to work better for certain client subgroups (e.g., children of certain ages, children with normal language) and to address certain goals (e.g., reduce inconsistent speech production, improve prosody). This paper will use the ASHA (2004) levels of evidence to compare the overall treatment designs used in CAS treatment research. Currently there are no meta-analyses of RCTs (i.e., level Ia evidence), however this will soon be possible given growing RCT evidence (level IIb). For instance, recent RCTs include a comparison of the Nuffield Dyspraxia Programme-3rd edition (NDP3) and the Rapid Syllable Transition treatment (ReST; Murray et al., 2015). Likewise, there is a RCT in progress that use the NDP3 to compare different types of feedback (McKechnie et al., 2016), one of the key principles of motor learning. There is also a RCT underway that compares ReST versus ultrasound treatment (McCabe, Preston, & Evans, 2016). There is level IIa evidence (i.e., pre-post group comparison design without randomisation of participants) for the Motor Speech Treatment Protocol (MSTP; Namasivayam, Pukonen, Goshulak, et al., 2015) as well as several multiple baseline single subject designs for Dynamic Temporal and Tactile Cueing (DTTC) replicated across research groups, which also constitute level IIb evidence (Edeal & Gildersleeve-Neumann, 2011; Maas & Farinella, 2012; Strand & Debertine, 2000). Additionally, the Integrated Phonological Awareness intervention and the Prompts for Restructuring Oral Muscular Phonetic Targets (PROMPT) has both level IIb and III evidence (McNeill, Gillon, & Dodd, 2009a, 2009b, 2010). Likewise, PROMPT therapy has level IIb and II evidence (Dale & Hayden, 2013; Kadis et al., 2014). Multiple treatments have level IIB evidence such as combined stimulability and core vocabulary treatment (Iuzzini & Forrest, 2010), melodic intonation therapy (Martikainen & Korpilahti, 2011), and approaches involving augmentative or alternative communication (AAC; Binger & Light, 2007; Binger, Maguire-Marshall, & Kent-Walsh, 2011). Level IV evidence is comprised of clinical expertise, such as expert committee reports. CAS treatment approaches with level IV evidence include the Kaufman Speech Praxis Kits (Kaufman, 1998a, 1998b) and treatment approaches described in textbooks (e.g., Fish, 2010). Reviews of such treatment evidence (Kearney et al., 2015; Morgan & Vogel, 2008; Murray et al., 2014; Watts, 2009), the ASHA Practice Portal (ASHA, 2017) and the ASHA Evidence Maps for CAS (ASHA, n.d.) are available to help collate this information. Not every treatment associated with CAS is described here, but rather those that are considered to have the best evidence for a specific area of functioning or those that pose contradindications or have limitations on their use (Murray et al., 2014).

It is difficult to determine how long and how much intervention a child with CAS may need as there are few longitudinal studies available (e.g., Lewis, Freebairn, Hansen, Taylor, et al., 2004; Marquardt, Jacks, & Davis, 2004; Stackhouse, 1992). What is known is that treatment duration is likely to vary across individuals based on multiple factors, and treatment to obtain functional speech for children with CAS usually takes years (ASHA, 2007; Murray et al., 2014). In some cases, functional communication is best achieved through AAC modes such as communication boards or voice output devices (Bornman, Alant, & Meiring, 2001; Morgan & Vogel, 2008; Murray et al., 2014). By reviewing a child's assessments using the ICF framework, we can gauge a child's skills and needs over time to help us plan therapy for one or more areas of functioning.

Body Structures and Functions

Body Structures and Function: Orofacial

The CAS diagnosis is not associated with impaired oral-facial structures (e.g., cleft lip and palate, and submucous cleft palate), oral-motor/non-speech movement impairments (oral apraxia), or abnormal tone and execution of movements (e.g., dysarthria). However, a subset of children with CAS will present with co-morbid structural or functional orofacial impairments.

For children with comorbid CAS, treatment should address each impairment. There is no evidence that non-speech oral motor exercises improve speech skills in children with CAS (Forrest & Iuzzini, 2008; McCauley & Strand, 2008; Ruscello, 2008)—this is due to the fact that there are different neurological pathways for speech and non-speech movements so that working on non-speech skills will not affect change in speech skills.

The literature base of the comorbid impairments should also be considered in treatment planning. Where there is no external evidence that stipulates the specific timing of therapy for children with CAS and other comorbidities, clinical expertise suggests that structural impairments need to be managed first—for example, a child should be treated for a hearing impairment so they can perceive and imitate during therapy. Likewise, a child with a cleft palate will ideally have started their cleft repair process prior to therapy so he/she can learn to use the velum as an articulator and develop motor plans that include the velum in real time. Dysarthria may also need to be managed first or concurrently, particularly if there is a respiratory or phonatory component. Dysarthria therapies with external evidence that work on body structures and functions include the Lee Silverman Voice Therapy for pediatric spastic and ataxic dysarthria (Levy, 2014; Levy, Ramig, & Camarata, 2012; Sapir, Ramig, & Fox, 2011), the Systems/Brief Intensive Approach (Pennington, Miller, Robson, & Steen, 2010; Pennington et al., 2013; Pennington, Smallman, & Farrier, 2006), and the Speech Systems Intelligibility Treatment (Levy, 2014).

Body Structures and Function: Motor Planning and Programming

The motor planning and programming deficit associated with CAS is attributed to an impairment of the structure or function of the central nervous system, although the specific substrates are under ongoing research (Morgan, Bonthrone, & Liégeois, 2016). The majority of the treatments for CAS address the accuracy of motor speech skills and movement planning and programming. This includes biofeedback approaches such as electropalatography or ultrasound (Lundeborg & McAllister, 2007; Preston, Brick, & Landi, 2013); articulation, tactile and multi-sensory cueing such as DTTC (Maas & Farinella, 2012; Strand & Debertine, 2000), and treatment to address rate and dysprosody (Ballard, Robin, McCabe, & McDonald, 2010; Helfrich-Miller, 1994). Most treatments use stimuli and outcome measures based on whole word/item accuracy and require that children with CAS are consistently accurate based on accurate production of consonants, vowels, sound sequencing, and prosody (Murray et al., 2015; Strand & Debertine, 2000). This is logical in establishing motor plans and programs because addressing only one speech aspect (e.g., consonant production) could require that later the same stimulus item may need to be targeted for a different speech aspect (e.g., prosody or resonance).

To select the best motor treatment for an individual client, it is essential to first determine your client's specific needs and goals and then to choose the treatment that best aligns. Below we outline the specific goals of several evidence-based motor treatments. See Table 1 for a comparison of these treatments and their evidence.

- The Dynamic Temporal and Tactile Cueing (DTTC) treatment is based on Integral Stimulation (Edeal & Gildersleeve-Neumann, 2011; Maas & Farinella, 2012; Strand & Debertine, 2000) and concurrently addresses articulation and prosodic accuracy. Simultaneous imitation and touch cues are used to work towards independent productions. Real, functional or strategically chosen (e.g., with specific sound targets like clusters) words or phrases are trained in drill practice. Outcomes across studies, that were assessed in a systematic review for nine participants across four studies, demonstrate moderate-to-large treatment and generalisation effects (Murray et al., 2014). A manual is forthcoming and a book chapter helps to provide administration details in the meantime (Strand & Skinder, 1999). Professor Edythe Strand also has YouTube videos on DTTC (Mayo Clinic, 2015).
- The Motor Speech Treatment Protocol (MSTP) aims to improve intelligibility (Namasivayam, Pukonen, Goshulak, et al., 2015; Namasivayam, Pukonen, Hard, et al., 2015) by incorporating principles of motor learning (Maas, Robin, Wright, & Ballard, 2008), temporal cueing, integral stimulation (Strand & Debertine, 2000), and touch cues (Hayden, 2006) in drill and play activities. A single-subject multiple baseline design showed significant changes for 4/5 participants (Namasivayam, Pukonen, Hard, et al., 2015) and a non-RCT with 37 participants showed significant changes in articulation and functional communication for the group given treatment twice a week, however no changes were observed for the group given therapy only once per week. In addition, no changes to sentence intelligibility were observed for either group (Namasivayam, Pukonen, Goshulak, et al., 2015).
- The Nuffield Dyspraxia Programme (3rd edition, NDP3; Williams & Stephens, 2009) is a commercial, comprehensive program that addresses articulation, sequencing, and prosody in sounds and real words during drill play activities using a psycholinguistic framework. Clinicians target three goals selected from a hierarchy of sounds/word shapes/phrases of increasing complexity. This treatment has demonstrated significant and large treatment effects and moderate generalization to real words for 13 participants with CAS (Murray et al., 2015). Similar results were replicated in a second RCT (14 participants) that demonstrated different learning trajectories based on different types of feedback. Findings showed that children who received more knowledge of performance feedback acquired targets faster than those who received knowledge of results, who instead showed greater maintenance and generalisation (McKechnie et al., 2016). Some older children (8–12 years) who worked on higher levels of the hierarchy showed some decline in performance compared to posttreatment outcomes when retested at four months posttreatment (Murray, McKechnie, & Williams, 2017). All still showed

significant improvement compared to pre-treatment performance. The Nuffield Dyspraxia Programme resources are available from the website (NPD3, 2016) and more instructions on administering the treatment can be found in Murray, McCabe, and Ballard (2012).

- PROMPT treatment uses four levels of tactile kinaesthetic cues to help children feel how their articulators need to move across sounds in real time within functional movement goals in words or phrases. The treatment addresses physical-sensory skills as well as cognitive-linguistic and emotional-social domains (Hayden, 2006). Evidence for using this treatment with children with CAS is limited to two studies. One is a pre-post within group (case series) design in which 12 participants with idiopathic CAS demonstrated change in articulation and sequencing scores and also changes in changes in cortical thickness (Kadis et al, 2014). The other is single-case designs containing six participants, demonstrating changes in intelligibility and posttreatment (Dale & Hayden, 2013). PROMPT has greater evidence for children with cerebral palsy and other developmental motor disorders (e.g., Grigos, Hayden, & Eigen, 2010; Ward, Leitão, & Strauss, 2014) compared to the extant research on PROMPT for children with CAS. Clinicians need to complete post-degree training to use PROMPT. Resources and training information can be found at The PROMPT Institute (n.d.).

- ReST is based on principles of motor learning and theory and addresses lexical stress, articulation, and sequencing in pseudowords in a drill format. Multiple studies, including a published RCT with 34 participants, have shown significant gains in treated items with large effect sizes and moderate generalisation to real words for the majority of participants (Ballard et al., 2010; McCabe, Macdonald-DaSilva, van Rees, Ballard, & Arciuli, 2014; Murray et al., 2015; Thomas, McCabe, & Ballard, 2014; Thomas, McCabe, Ballard, & Lincoln, 2016). Therapy administered twice a week yields similar treatment and generalisation gains (no direct comparison was made) to therapy administered four times a week (Thomas et al., 2014). In addition, telehealth delivery is a viable option (Thomas et al., 2016). The University of Sydney provides training materials and videos of therapy that are freely available (McCabe, Thomas, Murray, Crocco, & Madill, 2017). Methods are also available in an open-access protocol (Murray et al., 2012).

- Ultrasound biofeedback uses visual biofeedback of the tongue posture to show children how to articulate lingual phones such as [/s/] and [/r/], as well as clusters and vowels in words in a drill format. This also incorporates principles of motor learning and targets some prosodic cues (e.g., statements versus questions and emphatic stress). Findings show that ultrasound treatment demonstrated effective and rapid gains (average five sessions needed) to treated sound sequences and generalization to untrained items for six participants (Preston et al., 2013). Additional research in populations with residual errors, but not CAS, has shown that many (but not all) participants respond to ultrasound biofeedback in prepractice (Preston, Leece, & Maas, 2016; Preston et al., 2014). Haskins Laboratories (2014) provides additional research and materials.

Table 1. Comparison of Treatments for CAS Across the ICF With Evidence Base.

ICF Section	Treatment Subarea	Treatment Approach(es)	Description	Published Papers	Level of Evidence (ASHA, 2004)	Clients Suitable (Including Comorbidities)
Body Structures	Nonspeech oral motor skills	Nonspeech oral motor treatments	Aims to strengthen and increase range of movement of specific articulators (e.g., blowing through straws for lip rounding/closure)	Forrest & Iuzzini (2008); McCauley & Strand, (2008); Ruscello, (2008)	III/IV	Not for children with CAS.
Body Structures and Functions (Neurological)	Articulation and prosodic accuracy	Dynamic Temporal and Tactile Cueing (DTTC)	Aims for practice of specific movement gestures for speech production and improved motor planning/programming in functional words or specific stimuli with imitation and touch cues to reduce errors.	Baas et al. (2008); Edeal & Gildersleeve-Neumann (2011); Maas, Butalla, & Farinella (2012); Maas & Farinella (2012); Strand & Debertine (2000); Strand, Stoeckel, & Baas (2006)	IIb - Multiple baseline design (replicated across research groups)	3- to 8-year-olds with idiopathic or comorbid CAS (dysarthria, linguistic, or cognitive impairment)
	Prosodic and articulation accuracy	Rapid Syllable Transition treatment (ReST)	Aims for improved motor planning/programming of rapidly sequencing nonsense syllables and segments with accurate realisation of lexical/word stress.	Ballard et al. (2010); McCabe et al. (2014); Murray et al. (2015); Thomas et al. (2014); Thomas et al. (2016)	Ib - Randomised control trial	4- to 12- year-olds with mild to severe idiopathic CAS
	Articulation accuracy	Motor Speech Treatment Protocol (MSTP)	Aims to improve intelligibility and functional, verbal communication through motor practice in craft activities with PROMPT therapy features.	Namasivayam, Pukonen, Goshulak, et al. (2015); Namasivayam, Pukonen, Hard, et al. (2015)	IIa – Pre-post group comparison design with no randomisation of participants and IIb – single-subject design	2-;8- to 4-;8- year-olds with CAS (severity not reported).

	Articulation, prosody and linguistic function accuracy	Nuffield Dyspraxia Programme – 3rd edition (NDP3)	Aims to holistically address the child2's speech difficulties using a hierarchical and psycholinguistic approach, real words and multiple cueing strategies.	Murray et al. (2015)	Ib - Randomised control trial	4- to 12-year-olds with mild to severe idiopathic CAS
	Articulation accuracy	Ultrasound	Aims to improve articulation of lingual speech errors at a time using principles of motor learning (e.g. /r/, /s/, /tʃ/, /ʤ/, /r/ and vowels).	Preston et al. (2013)	IIb - Multiple baseline design	9- to 15-year-olds with mild-severe comorbid CAS (including PPD-not otherwise specified, ADHD, dysarthria, Trisomy 8)
	Movement/ articulation accuracy	PROMPT	Aims to improve functional communication goals and stimuli with tactile-kinesthetic and auditory cues for movement accuracy.	Dale & Hayden (2013); Kadis et al. (2014)	IIb/III– multiple baseline designs, pre-post design studies	3- to 6-year-olds with CAS
Mental (linguistic) Functions	Phonological awareness	Integrated Phonological Awareness	To improve phonological awareness (e.g., sound-to-letter correspondence, segmenting, blending) to promote early literacy while also working on speech sounds in error.	McNeill et al. (2009a, 2009b, 2010); Moriarty & Gillon (2006)	IIb/III – Single case/pre-post group studies	4- to 7-year-olds with CAS; however, phonological errors primary diagnosis
Activities and Participation	Intelligibility	Motor-based treatments	Aims for intelligibility (PROMPT, MSTP) or whole word/phrase accuracy (DTTC, ReST, NDP3, ultrasound)	See above motor treatments for details		
	Multi-modal/ augmentative and alternative treatment	Aided AAC Modeling	Aims to teach children to use communication boards or voice output devices to communicate and learn and use trained language features.	Binger, Kent-Walsh, Berens, Del Campo, & Rivera (2008); Binger & Light (2007); Binger et al. (2011)	III – pre-post	Children with severe CAS aged 3;4–6 years (comorbid disorders include cognition, language, and velocardiofacial syndrome)

Principles of Motor Learning to Facilitate Treatment Success. Motor-based treatments incorporate principles of motor learning to maximize learning and generalization (see Maas, Robin, Austermann Hula, et al., 2008 for a review; Murray et al., 2015; Schmidt & Lee, 2011). These treatments typically start with a pre-practice phase in which the child acquires the motor skill (e.g., a specific phonemic or word target) by relying on instructions and establishing what is "correct," through stimulability and cueing, and specific knowledge of performance feedback (Maas et al., 2008; McIlwaine, Madill, & McCabe, 2010). After a child acquires the target, ideally a practice phase is used to facilitate learning and retention. The practice phase includes use of a high number of practice trials, distributed practice over a longer period of time (e.g., multiple shorter sessions per week rather than one longer session per week), variable practice opportunities wherein a variety of stimuli and contexts are trained, a random practice schedule where stimuli are presented in random order rather than practicing one stimuli item repeatedly before proceeding to the next stimuli item, external attentional focus (focus on effects of movements rather than the movements themselves), and training of complex targets rather than simple targets (Maas et al., 2008; Wulf, Shea, & Lewthwaite, 2010). The feedback provided is knowledge of results (Maas et al., 2008, p. 282) in which only the outcome of the production (correct/incorrect) is given after a brief delay (i.e., 3–5 seconds) and only after some productions (e.g., for 50% of responses, or as summative feedback after 5 or 10 responses). For example, if a child says "banana" as "ba-na-na," the clinician would say "not that time" after counting to three in their head if it was marked as a feedback production on their data sheet. If it was not marked, a clinician would give no response and move onto the next stimulus item. This is in contrast to knowledge of performance feedback in which specific feedback is given after every practice trial. Using the same example (if a child said "banana" as "ba-na-na") specific feedback could be "that word sounded broken up, can you put the sounds together?" followed by models and cues as needed. Practice accounts for the majority of the session and/or therapy block. Some CAS treatments explicitly move from pre-practice to practice (e.g., ReST), some use pre-practice that fades to practice (e.g., DTTC), and others use only pre-practice (e.g., NDP3).

There are studies that have deliberately manipulated one principle of motor learning within DTTC treatment and found mixed results (Maas, Butalla, & Farinella, 2012; Maas & Farinella, 2012). For example, Maas and Farinella (2012) investigated the effects of random versus blocked practice in four children with CAS. Findings revealed that two participants with CAS evidenced greater gains with blocked practice (repetitive training of the one item), one showed greater gains with random practice, and one child evidenced no difference between conditions (Maas & Farinella, 2012). Variable response was also found for feedback frequency with two participants showing greater change for low frequency feedback, one showing greater response for high frequency feedback and one showing no improvement (Maas, Butalla, & Farinella, 2012).

The principle of motor learning that has the greatest evidence supporting its use in children with CAS is that of treatment intensity—where a higher number of sessions and practice trials per session results in the greatest gains within one block of treatment. The minimum intensity that has been shown to work is two sessions a week (Namasivayam, Pukonen, Goshulak, et al., 2015; Thomas, McCabe, & Ballard, 2014) with most articles employing sessions 3–5 times a week and 100 production trials per session (Edeal & Gildersleeve-Neumann, 2011; Murray et al., 2015).

Body Structures and Functions: Fine and Gross Motor Skills

Children with CAS can also present with fine and gross motor impairments (Gretz, 2013; Iuzzini-Seigel, Delaney, & Kent, 2016) including developmental coordination disorder (the updated term and criteria for motor dyspraxia); however not all children will have both disorders. In addition, there is some evidence that children with CAS may also have sensory difficulties that could require occupational therapy (Newmeyer et al., 2009). These aspects are best assessed by an occupational and/or physical therapist and may also require treatment.

Body (Mental) Functions: Language

There is continued debate about whether linguistic deficits are core impairments of CAS in addition to motor planning and programming deficits. For example, the Royal College of Speech Language Therapists Position Statement on Developmental Verbal Dyspraxia (used synonymously for CAS, but excludes acquired cases), lists motor and linguistic features as the basis of the disorder (RCSLT, 2011). Some—but not all—children with CAS can present with difficulties in phonology, grammar, morphosyntax and/or phonological awareness skills (manipulating sound skills needed for early reading and writing; Gillon & Moriarty, 2007; Lewis, Freebairn, Hansen, Iyengar, & Taylor, 2004; Stackhouse & Snowling, 1992). Assessment of these areas is required and intervention may be completed using linguistic stimuli in a motor-based treatment or a specific linguistic treatment. Examples of treatments that simultaneously target the linguistic and motor systems include the NDP3 and DTTC programs using specific phonological or morphological stimuli, and the combined stimulability and modified core vocabulary approach to increase speech sound consistency and expand the phonemic inventory (Iuzzini & Forrest, 2010).

The linguistic treatment that has the most evidence for CAS is the Integrated Phonological Awareness intervention (Gillon & Moriarty, 2007; McNeill et al., 2009a, 2009b, 2010). It uses minimal pairs to explicitly work on phonology and phonological awareness skills such as sound-to-letter links, blending, and segmentation simultaneously. Twelve children with reported CAS (but no prosodic impairments) showed moderate treatment gains and large generalization gains up to six months posttreatment (McNeill et al., 2009a; Murray et al., 2014). In addition, a long-term follow up showed improved reading and spelling skills in most participants (McNeill et al., 2009a, 2010). The resources for this treatment are freely available from on the University of Canterbury website (n.d.).

Activity and Participation

Children with CAS typically have low intelligibility as a result of their motor planning and programming impairment (and potential comorbidities), and may have difficulty conversing and socialising with a range of communication partners. Children with CAS must be able to communicate and get their message across even while their motor planning and programming is developing and their intelligibility is low. Likewise, it is essential that children in this population have the tools to engage in meaningful social interactions, thereby reducing frustration and helping them to further develop their language skills. These deficits may require social adaptations (e.g., slowing down songs and using actions for nursery rhymes sung at childcare to facilitate participation), training of communication partners (e.g., how to respond when a child is not understood), and AAC modes. There are many AAC options available, however these studies have low quality evidence, with poorly defined outcomes, a lack of experimental control and are limited to descriptive results. Additionally, the diagnosis of CAS has often been questionable in studies that examined AAC in this population (Murray et al., 2014). Options for AAC intervention include key word sign (Gretz, 2015; Tierney, Pitterle, Kurtz, Nakhla, & Todorow, 2016), communication boards, and voice output devices (e.g., Bornman et al., 2001; Culp, 1989). The best available evidence is Aided AAC Modeling intervention (e.g., Binger & Light, 2007; Binger et al., 2011) that uses communication boards or voice output devices to augment speech and simultaneously train specific language skills (e.g., morphological skills). This intervention was tested in English- and Spanish-speaking children with severe CAS and findings showed that participants increased their number of communicative messages via their AAC device in the course of one day of treatment and evidenced increased language skills and reduced frustration over the course of treatment.

As in children with other persistent speech sound disorders, the breadth of communication and global motor impairments may impact mental health as well as academic and career potential

(Beitchman et al., 2001; Felsenfeld, Broen, & McGue, 1994). These aspects need to be considered and if possible preventative work should be done to avoid later risk factors.

Personal and Environmental Factors

There is still a need for more research that determines which children will respond better to different treatments. Personal factors such as comorbid disorders or personality traits may be important in selecting which treatment could assist particular individuals. Historically, most treatment research has been limited to children with CAS and no other diagnoses. Recent research on DTTC, however, showed treatment gains for children with CAS and comorbid dysarthria (Baas, Strand, Leanne, & Barbaresi, 2008; Maas, Butalla, & Farinella, 2012; Maas & Farinella, 2012). Likewise, children with CAS and phonological impairment were shown to benefit from Integrated Phonological Awareness intervention (McNeill et al., 2009a). Table 1 shows which treatments are recommended for children of different ages and severity levels (with any comorbidities tested) and can be used as a guide.

Personal characteristics such as the child's personality (e.g., is child a "risk taker" versus a child with a "fear of failure") or their attentional capacity may also influence treatment outcomes. This is seen in research on children with phonological disorders (see Baker & McLeod, 2011a; 2011b for reviews). For example, an approach like DTTC or PROMPT that offers preemptive supportive cueing to ensure successful productions may work better for a client who has fear of failure than an approach that offers cues in response to incorrect productions (e.g., NDP3 or ReST).

It is also important to regularly reassess children's skills and needs (e.g., at the start and end of therapy blocks) as their treatment needs, priorities, and therefore approaches may change over time. There are multiple treatments available that have different goals, stimuli, and cues, and this offers choice based on a child's evolving needs.

Additionally, we need to consider the impact of CAS on the family unit. There are excellent resources available for families through the Childhood Apraxia of Speech Association of North America website (2017). Family support, education and training is also recommended at the time of diagnosis and at different periods during therapy to help caregivers work with their child (McCormack, McAllister, McLeod, & Harrison, 2012; Miron, 2012). A psychologist or social worker may also be useful to families.

Environmental factors such as access to early intervention, funding and services, can also impact remediation. These issues are commonly discussed on the Apraxia Kids (2017) website and support Listserv. A survey by Ruggero, McCabe, Ballard, and Munro (2012) revealed that caregivers report concern they cannot access appropriate, intensive services for their children with CAS. Service delivery options, such as telehealth for children aged five years or over (Thomas et al., 2016) and tablet-based therapy (McKechnie et al., 2016), are now being explored and show similar success rates to clinician driven face-to-face therapy. The only limit to telehealth appears to be treatment for resonance due to the sound quality of available systems. A child's caregivers can also have an impact on remediation as some families may be able to assist with home practice whereas others may not have the time or skillset to provide home practice opportunities. Further studies exploring training of caregivers, therapy aids and community-based therapists in CAS treatment are needed.

Working With Other Professionals

As previously discussed, children with CAS can also present with comorbid disorders, not just in communication but in other areas as well. Interdisciplinary teams may be required for children with CAS—for example physical therapists and occupational therapists may be needed to address gross and fine motor skills and sensory processing issues (e.g., Newmeyer et al., 2009). Some children with CAS may also benefit from a wider developmental assessment by a pediatrician or an educational psychologist. If children do present with cleft palate concerns or significant resonance issues, an ear, nose and throat specialist may also be helpful. Finally for all children with CAS, a consult by a neurologist and/or geneticist may become more common as our knowledge of neural and genetic correlates improves (Liégeois & Morgan, 2012). Coordination and communication across services is important when working with families.

Conclusion

The ICF demonstrates that children with CAS have primary treatment priorities in addressing neurological body structures and functions in motor planning and programming. There are multiple evidence-based treatments available for children with CAS that address motor planning and programming and the range of symptoms seen in CAS, and are not limited to articulation alone (see Table 1). Children may also have comorbidities such as fine and gross motor deficits, sensory impairments, and cognitive-linguistic disorders that also require assessment and consideration. Maximizing a child's activities and participation, by increasing social communication, is crucial and AAC systems may support everyday communication while motor speech skills are developing. To date, no one treatment is known to work for all children with CAS. Table 1 details the CAS treatments with current best evidence. We continue to need more treatment and translational research to support treatment planning and determine which children will respond most favorably to which treatments. While this research often occurs at research institutions, it can also come from clinical practitioners who use these treatments in their practices and share their experiences with the profession.

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